Illinois State Geological Survey
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Training the Next Generation of Geoscientists to Solve Real-world Environmental Problems using Advanced Techniques: Year Two Report

Fiscal Year 2003 Report
Illinois Board of Higher Education

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The ISGS-University Applied Geophysics Training Program, just completing its second year of operation, has achieved successes in all three of its primary objectives: education, geoscience research, and applied geophysics method development. Field work, supervised by professional scientists, adds to and reinforces the educational experience of classroom studies. The field projects are chosen from existing research agendas at either the ISGS or the cooperating university so that the projects have real-world significance and integrate into other programs, thus multiplying the benefit of the work. Students are trained to use the most up-to-date methods to solve real-world problems. In order to provide cutting-edge training, new and innovative geophysical techniques are developed and tailored to these projects.

Objective 1. Education

Solving modern geoscience problems requires the ability to apply a variety of techniques to the problem. In the ISGS-University Applied Geophysics Training Program, advanced geophysical methods are emphasized, but students are also exposed to the wide range of other research tools that are needed to reach a sound scientific conclusion. Students practice newly developed geophysical techniques that allow them to image the subsurface with remarkable resolution. The students also use other geoscience methods such as drill core sampling and description, traditional geologic field mapping, groundwater geochemical sampling, and analysis.

During the program's second year, eighteen undergraduate and graduate students from **Illinois State University** (ISU) and the **University of Illinois** (UIUC) were involved in various aspects of the program. Some graduate students who learned basic techniques as undergraduates the previous year continued in the program the second year. Four graduate students are using data collected this year or last to develop master's thesis research. Professors Robert Nelson (ISU), David Malone (ISU), and Albert Hsui (UIUC) have contributed greatly to the success of this program. A list of publications related to this project is provided at the end of this report.

Figure 1. Students describing and packing core samples

Objective 2 Geoscience Research

Because we had the benefit of second-year students in the program, we were able to develop two new research projects this year and provide follow-up to research begun last year. In northwestern Champaign County, a hydrogeologic investigation of the Mahomet aquifer extends a project begun last year in Piatt County to a new field area. The second new project, located in LaSalle and Putnam Counties, incorporates both hydrogeology and geologic mapping.

Hydrogeology

Ancient river valleys, subsequently buried by Quaternary deposits by glaciers, are important groundwater resources throughout the Midwest. These valleys, buried as much as 400 ft deep, provide groundwater for many communities in Illinois. We have been able to use recently developed geophysical techniques to image both the structure of the aquifers and the recharge pathways that link surface water to the aquifers. We have found that the ancient valleys often had steep walls that produced sharp discontinuities in the hydrogeologic materials. As we examined these structures at a level of detail that can only come with the geophysical methods, we saw structures that could only be hypothesized before.

Geologic mapping

As part of an ongoing geologic mapping program, the geophysical techniques allow us to document the interrelationship between the surface and buried features. For example, we found a unique juxtaposition of a buried valley with a modern valley that cuts down into the ancient one in the LaSalle/Putnam County field area.

During this field season, we acquired 22 miles of high-resolution seismic reflection profiles over two buried valleys: the Mahomet Valley (Champaign County) and the Ticona Valley (LaSalle County). We have mapped the bedrock and aquifers from the surface down to 400 ft below the surface.

Figure 2. ISU students learn geophysical data acquisition techniques.

Objective 3. Applied Geophysics Method Development

The seismic reflection method, which sends sound waves down into the ground and records their reflection off subsurface materials, was developed by the oil industry to image deep subsurface structures. This program allowed us to customize the seismic reflection method for groundwater and geologic mapping projects. In 2000, as we began using standard high-resolution seismic reflection techniques, the acquisition rate was approximately of ¼ mile per day using four people. By using up to eight people, the maximum performance using those methods was improved to1¼ mile per day. We have developed a new approach to data acquisition, the landstreamer, that has improved the acquisition rate to a maximum of **2** miles per day using three to four people. This new technique is rapid and simple enough that students can operate the system with minimal supervision.

Figure 3. The landstreamer system operated by students to acquire reflection data.

This project allowed us to refine the high-resolution seismic reflection technique so that large areas can be mapped at an affordable price. Now the seismic reflection technique can be applied on a large scale to enhance geologic mapping programs. This technique has become very popular with the students who can easily see themselves using these new techniques in their careers.

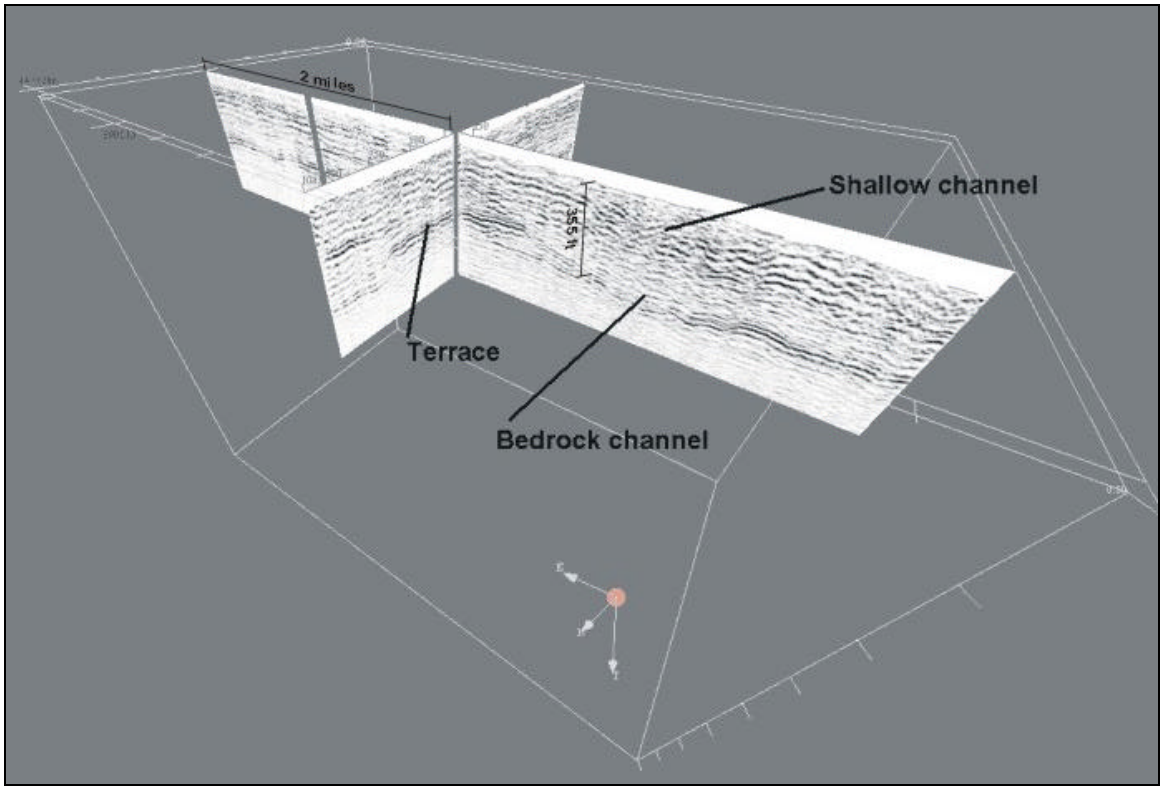

Figure 4. Three-dimensional view of seismic sections, a buried bedrock channel, and a buried terrace. The channel and terrace are, respectively, 380 ft and 310 ft deep.

Publications

Several published abstracts and posters related to this project were developed by the professors, researchers and students:

Carstens, D.A. and R.S. Nelson, 2002, Hydrologic characteristics of the Mahomet aquifer in the Allerton Park area, Piatt County, Illinois: Abstracts with Program, GSA Annual Meeting Denver, October 27-30, 2002.

Larson, T.H., and A.J.M. Pugin, 2002, High-resolution geophysical imaging of glacial aquifers in Illinois: Abstracts with Program of the National Ground Water Association Midwest FOCUS Ground Water Conference, Chicago, IL, April 11-12, 2002, p. 24.

Larson, T.H., and A.J.M. Pugin, 2003, Seismic imaging of methane in small glacial drift reservoirs, Piatt County, Illinois: GSA North-Central Section Annual Meeting, March 24-25, 2003.

Nelson, R.S., A. Pugin, T.H. Larson, 2002, Illinois State Geological Survey-Illinois State University collaborative geophysics project: Abstracts with Program, GSA Annual Meeting, Denver, October 27-30 2002.

Opokuah D., A. Pugin, R. Nelson, 2002, High resolution seismic mapping of the Mahomet Valley aquifer: Abstracts with Program, GSA Annual Meeting, Denver, October 27-30, 2002.

Pugin A., Larson, T.H., 2002, Geological mapping using geophysics, Three-dimensional geological mapping for groundwater applications: Abstracts with Program, GSA Annual Meeting, Denver, October 26, 2002.

Pugin A., T. Larson, H. Sargent, J.. Sieving, A. J. Stumpf, T.C. Young, and R.S. Nelson, 2002, Extensive geophysical mapping of the buried Teays-Mahomet Bedrock Valley reveals possible hydraulic window: Abstracts with Program, GSA Annual meeting Denver, October 27-30 2002.

Willems, B.A., T.H. Larson, A. Pugin, and D.H. Malone, 2002, A geophysical investigation into the lithology and stratigraphy of the Mahomet buried valley, Piatt, County, IL: Abstracts with Program, GSA Annual Meeting, Denver, October 27-30, 2002.

Conference or Poster with Expanded Abstracts

Pugin, A.J.M., 2002, Fold balancing to preserve amplitude of land-based shallow seismic reflection: SAGEEP Meeting, February 10-14, 2002, Las Vegas, Nevada, CD-ROM edition.

Pugin, A.J.M., T.H. Larson, and A. Phillips, 2002, Shallow high-resolution shear-wave seismic reflection acquisition using a land-streamer in the Mississippi River floodplain: Potential for engineering and hydrogeological applications: SAGEEP Meeting, February 10-14, 2002, Las Vegas, Nevada, CD-ROM edition.

Pugin, A.J.M., T.H. Larson, T.C. Young, S. Sargent, and R.S. Nelson, 2003, Extensive geophysical mapping of the buried Teays-Mahomet Bedrock Valley, Illinois: SAGEEP Meeting, April 5-10, 2003, San Antonio, Texas, CD-ROM edition.

Web site showing the landstreamer:

http://www.geometrics.com/html/andre.html